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Energy budget contextualization of fish biomasses at B_{MSY}

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Summary of Ecosystem Considerations

- Ecosystem approaches to Gulf of Maine/Georges Bank fisheries (TOR 3):
 - a.) Determine the production potential of the fishery based on food chain processes and estimate the aggregate yield from the ecosystem;
 - b.) Comment on aggregate single stock yield projections in relation to overall ecosystem production, identifying potential inconsistencies between the two approaches.

Model Structure

- Using EMAX balanced budgets for 4 NEUS regions, combined into one total
- Areally weighted for B, P/B, C/B
- Common diet with all nodes used from SNE
- Summed for fisheries and bycatch
- Used mass-balance eqns

$$C_i = P_i + R_i + E_i$$

- Used balancing routine

Main mass balance equation

$$B_i \left(\frac{P}{B} \right)_i * EE_i + IM_i + BA_i = \sum_j \left[B_j * \left(\frac{C}{B} \right)_j * DC_{ij} \right] + EM_i + C_i$$

Parameter	Abbreviation (units)	Parameter source
Biomass	B (t/km ²)	Data or model estimate: Survey estimates, sampling programs, stock assessments; estimated by fixing EE if no data available
Production/ Biomass	P/B (1/year)	Data: Mortality rates, growth rates, bioenergetics models
Consumption/ Biomass	C/B (1/year)	Data: Bioenergetics models, gut content analysis
Diet composition	DC (proportion by biomass/wet weight)	Data: Gut content analysis
Fisheries Catch	C (t/km ²)	Data: Fisheries statistics
Biomass Accumulation	BA (t/km ²)	Data: Biomass trend (only used if energetic demand requires it)
Immigration and Emigration	IM and EM (t/km ²)	Data: Used to specify annual net migration imbalance (not used in these models)
Ecotrophic Efficiency	EE (proportion)	Model estimate or assumption: Estimated by Ecopath; if no biomass data are available, EE is fixed at a standard level (0.9 here) to estimate biomass

Model Applications

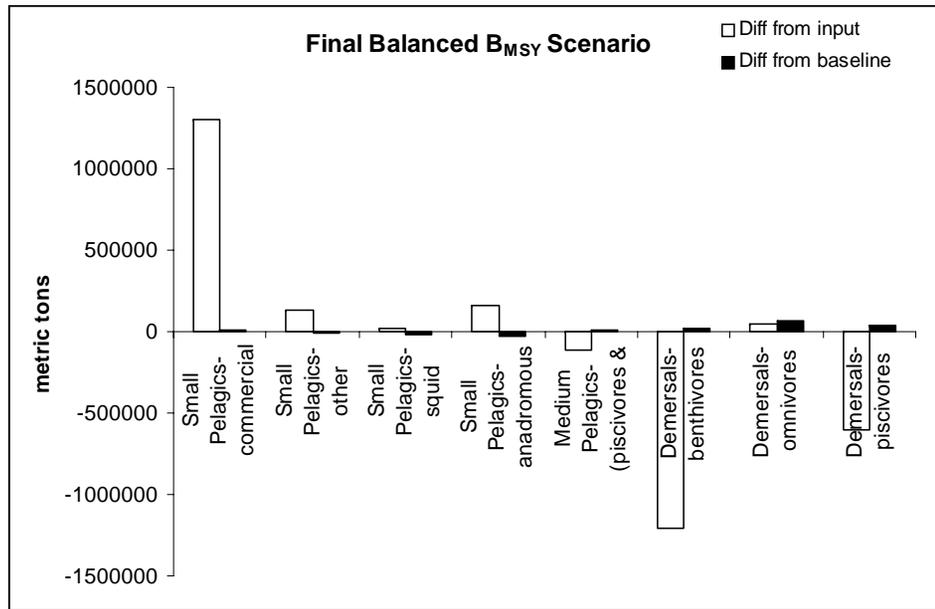
- Current Biomass combined for all 4 NEUS regions (see Link et al for details)
- Then balanced; this was used as baseline
- Main objective to ascertain effects of having fish nodes at B_{MSY}
- B_{MSY} for 8 fish groups (see Overholtz et al for calculations thereof)

Model Scenarios

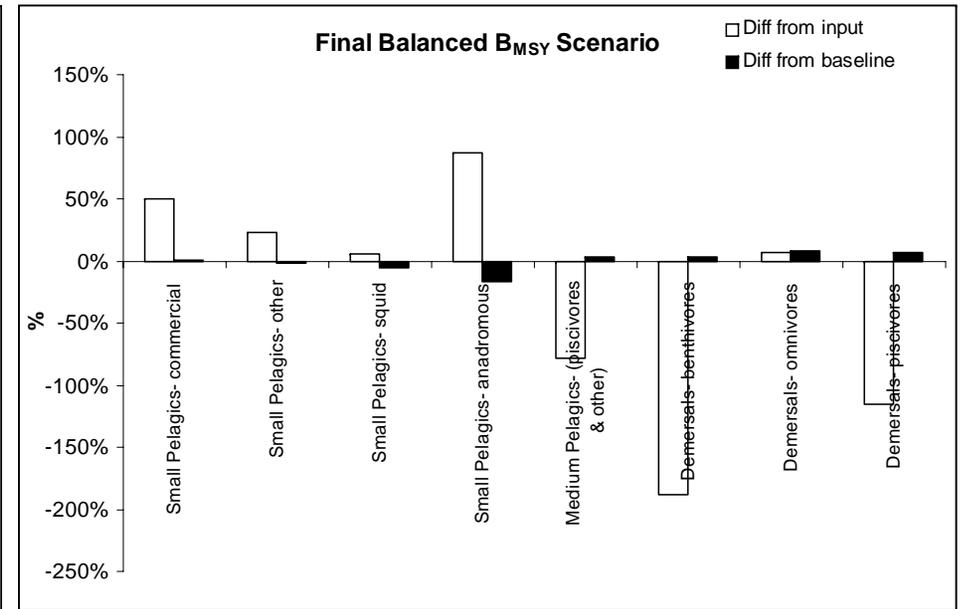
- B_{MSY} for 8 fish groups
- All pelagics B doubled from B_{MSY} values
- All pelagics B halved from B_{MSY} values
- All demersals B halved from B_{MSY} values
- Rebalanced each scenario
 - Compared difference from input & difference from current baseline
 - Locked P/B, C/B ratios

B_{MSY}

A

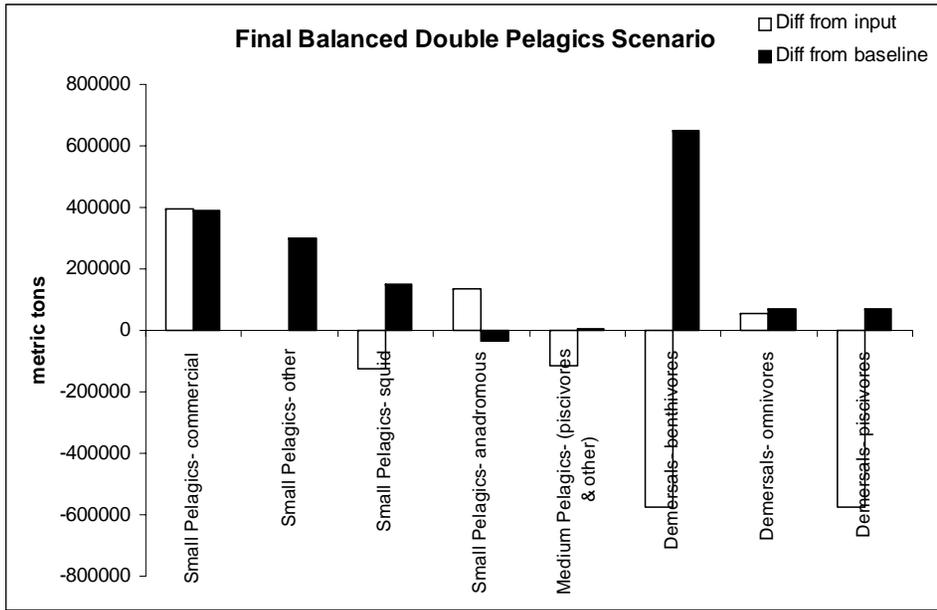


B

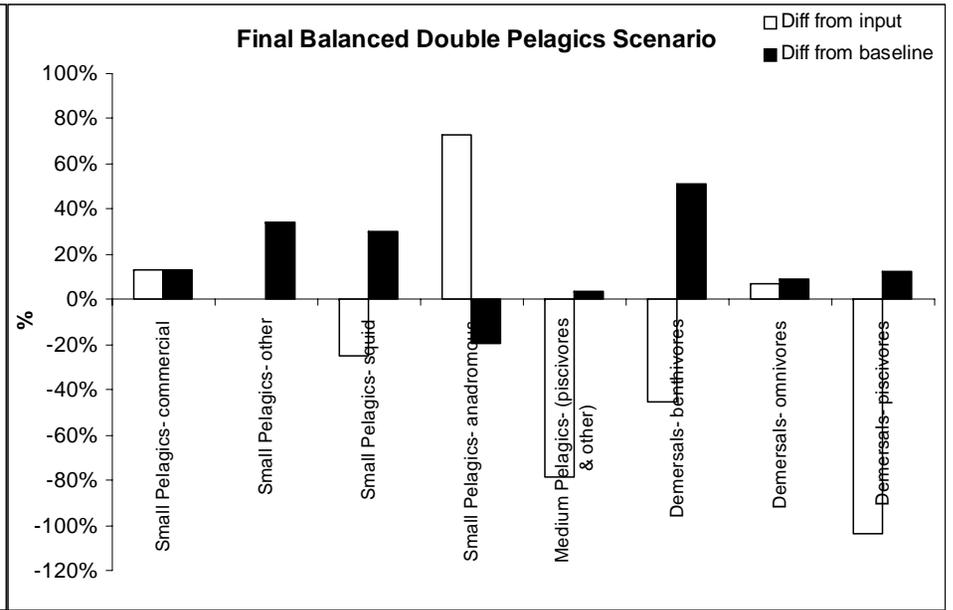


Double Pelagics

A

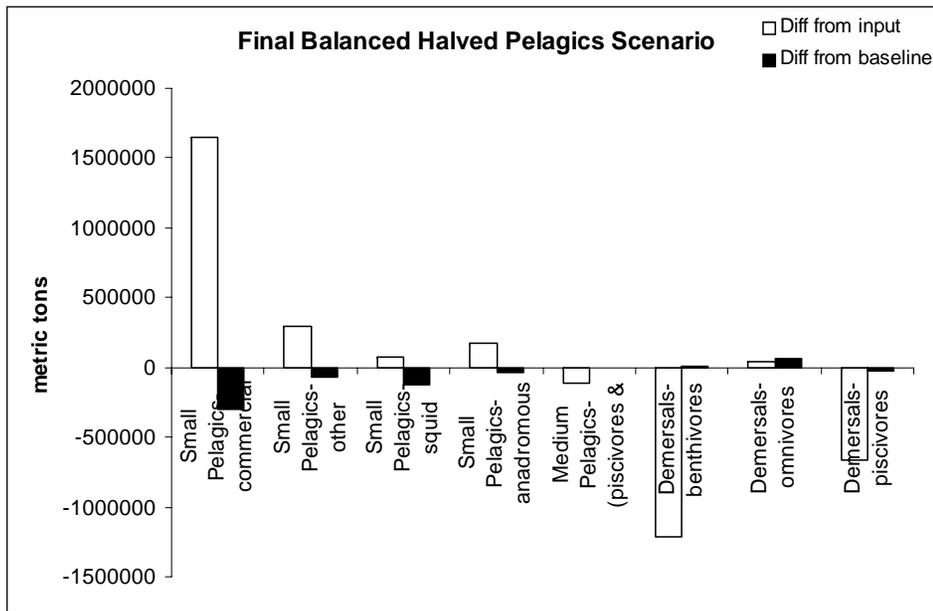


B

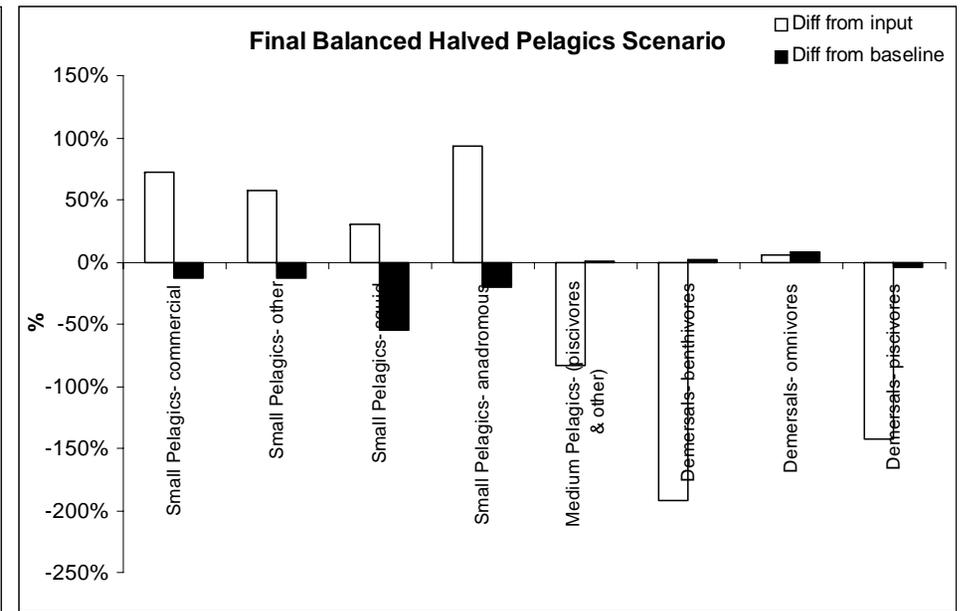


Halve Pelagics

A

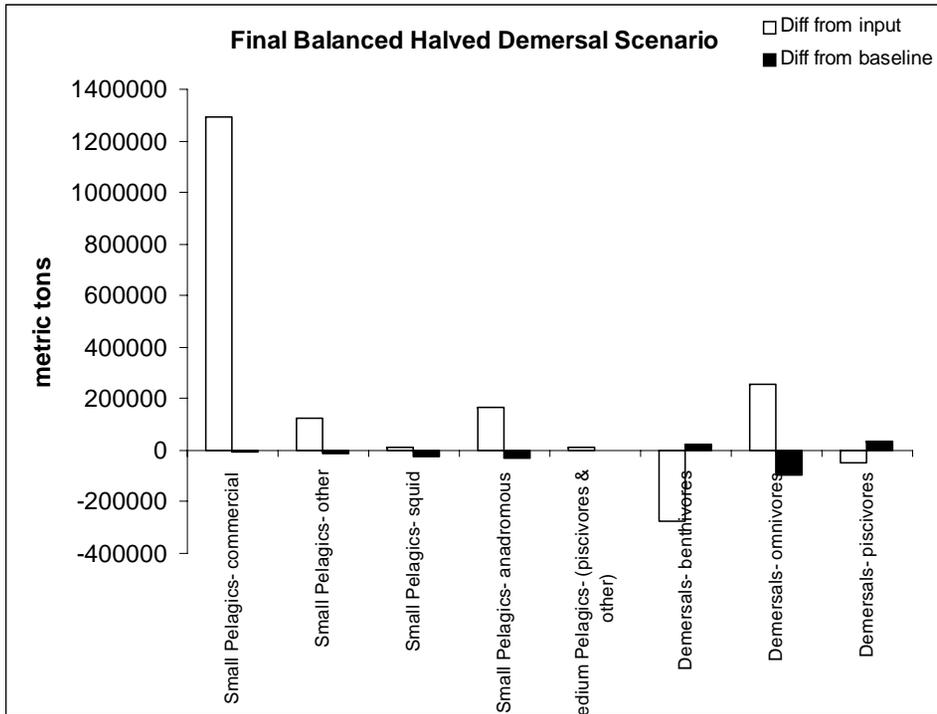


B

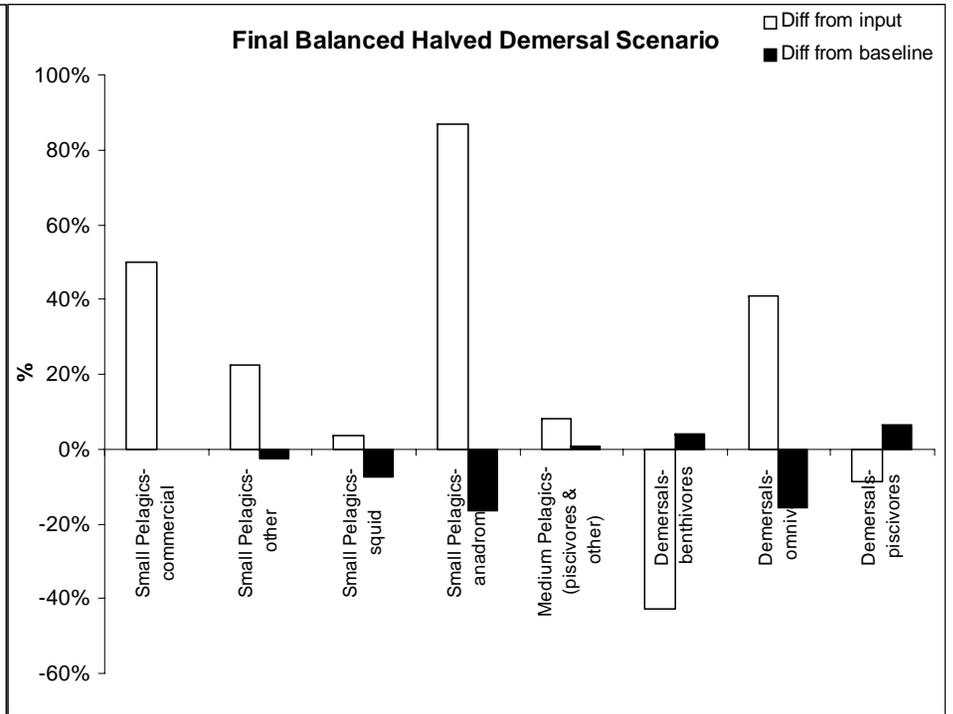


Halve Demersals

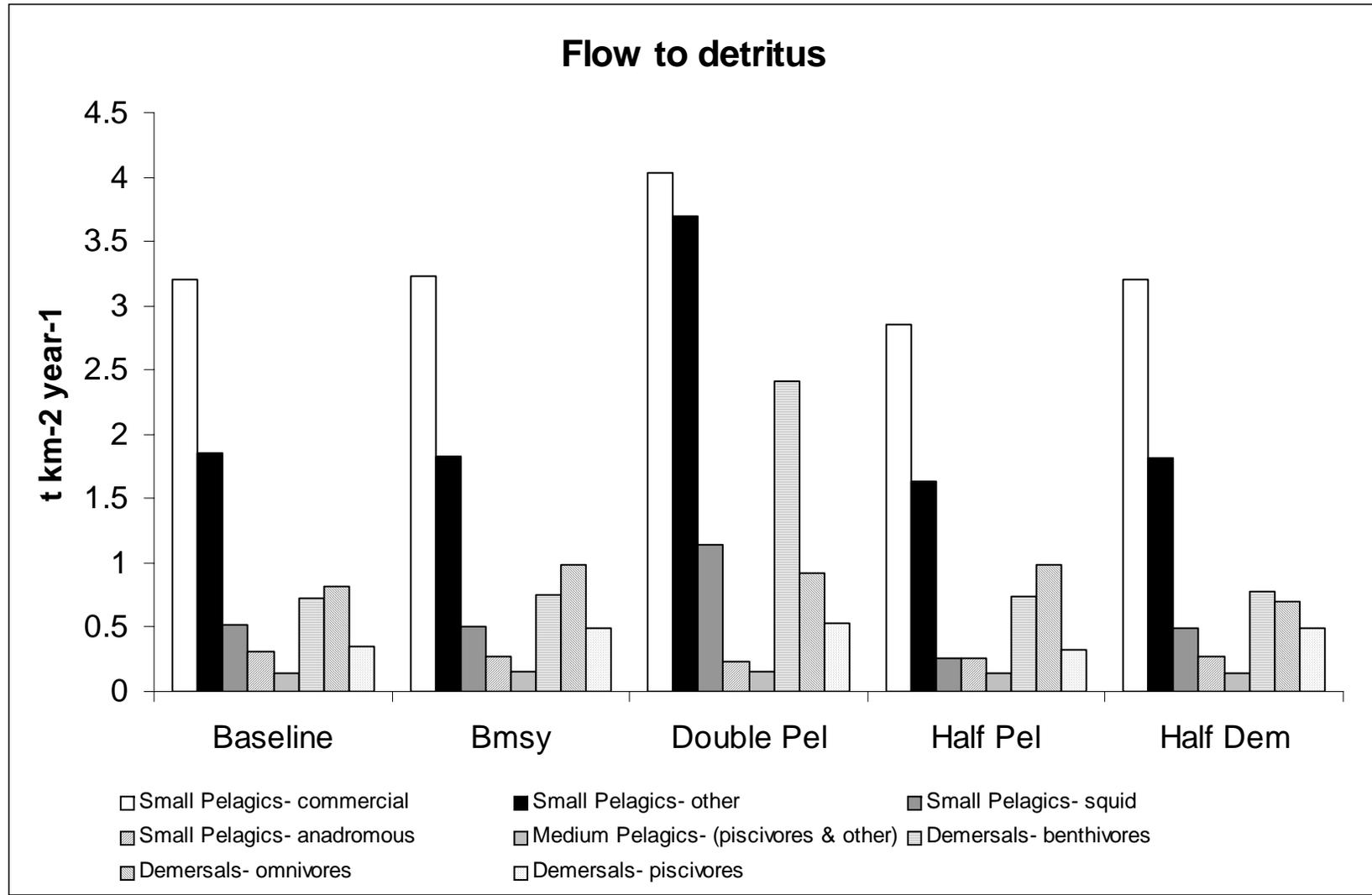
A



B



Tracking flows



Cybernetic Metrics

	Baseline	Bmsy	Double Pel	Half Pel	Half Dem
Sum of all consumption	7317.092	7312.478	7361.06	7296.269	7315.869
Sum of all exports	766.187	771.497	748.048	775.166	766.834
Sum of all respiratory flows	3460.682	3455.371	3478.825	3451.702	3460.035
Sum of all flows into detritus	4234.077	4239.554	4237.845	4243.863	4234.798
Total system throughput	15778	15779	15826	15767	15778
Sum of all production	6229	6229	6238	6221	6226
Mean trophic level of the catch	2.97	2.97	2.97	2.96	2.96
Gross efficiency (catch/net p.p.)	0.003434	0.003434	0.003434	0.003434	0.003434
Input total net primary production					
Calculated total net primary production	4227.27	4227.27	4227.27	4227.27	4227.27
Unaccounted primary production					
Total primary production/total respiration	1.222	1.223	1.215	1.225	1.222
Net system production	766.588	771.899	748.445	775.568	767.235
Total primary production/total biomass	27.33	27.241	26.041	27.679	27.446
Total biomass/total throughput	0.01	0.01	0.01	0.01	0.01
Total biomass (excluding detritus)	154.675	155.181	162.33	152.723	154.021
Total catches	14.518	14.518	14.518	14.518	14.518
Connectance Index	0.334	0.334	0.334	0.334	0.334
System Omnivory Index	0.282	0.284	0.283	0.278	0.281

Effectively, minimal changes

Summary Observations

	t km-2	Baseline	Bmsy	Double Pelagics	Halve Pelagics	Halve Demersals
Sum Pelagic Fish		15.156	14.96	18.427	13.035	14.85
Sum Demersal Fish		7.971	8.485	11.173	8.19	7.814
Sum Fish		23.127	23.445	29.6	21.225	22.664
	mt					
Sum Pelagic Fish		3738405	3690060	4545236	3215236	3662927
Sum Demersal Fish		1966140	2092925	2755951	2020159	1927415
Sum Fish		5704546	5782985	7301188	5235396	5590342

Except Doubling Pelagics Scenario, all outcomes quite similar; highlights importance of allocation of biomass among specific fish nodes.

Summary Observations

- Overall, results inconclusive given multiple caveats of network model
- Recall, just equilibrium rebalancing; doesn't account for responses in F
- Fish components of the system could be increased relative to current biomass levels
- Overall, scenarios had minimal change relative to balanced baseline

Summary Observations

- Unclear if B_{MSY} for all species is energy limited from a systemic perspective
- However, rebalancing relative to input levels suggests may not be able to have all fish spp at B_{MSY} due to flow constraints
- All scenarios were balanced largely predicated upon a higher small pelagic-comm biomass and a lower demersal-omniv. and pisc. biomass